Evaluate Factors Limiting Columbia River Gorge Chum Salmon Populations

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Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

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Evaluate Factors Limiting Columbia River Gorge Chum Salmon Populations

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FY 2002 Annual Report

Prepared by:

Nancy M. Uusitalo

U.S. Fish and Wildlife Service
Columbia River Fish Program Office
Habitat and Population Assessment Team
9317 N.E. Highway 99, Suite I
Vancouver, Washington 98665 USA

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Abstract

Adult and juvenile chum salmon were monitored from October 2001 through September 2002 to evaluate factors limiting production. In 2001, 6 and 69 adult chum salmon were captured in the Hardy Creek and Hamilton Springs weirs, respectively. In 2001, 285 and 328 chum salmon carcasses were recovered during spawning ground surveys in Hardy Creek and Hamilton Springs, respectively. Twenty-eight fish captured in the mainstem Columbia River, Hamilton Springs, and Hardy Creek were implanted with radio tags and tracked via an array of fixed aerial, underwater antennas and a mobile tracking unit. Using the Area-Under-the-Curve program population estimates of adult chum salmon were 835 in Hardy Creek and 617 in Hamilton Springs. Juvenile chum salmon migration was monitored from March – June 2002. Total catches for Hardy Creek and Hamilton Springs were 103,315 and 140,220, respectively. Estimates of juvenile chum salmon emigration were 450,195 (+/-21,793) in Hardy Creek and 561,462 (+/-21,423) in Hamilton Springs.

Introduction

Historically, chum salmon (*Oncorhynchus keta*) had the widest distribution of all Pacific salmon species, comprising up to 50% of annual biomass of the seven species and may have spawned as far up the Columbia River drainage as the Walla Walla River (Nehlsen et al. 1991). Although there is no historic run size data for Columbia River chum salmon, the maximum historical commercial fishery landings were approximately 700,000 fish in 1928 (Columbia Basin Fish and Wildlife Authority (CBFWA) 1991). By the 1950s, landings declined dramatically to 10,000 fish annually (CBFWA 1991). On May 24, 1999, the National Marine Fisheries Service (NMFS) listed the Columbia River chum salmon Evolutionary Significant Unit (ESU) as threatened under the Endangered Species Act (NMFS 1999).

Chum salmon are primarily limited to the tributaries downstream of Bonneville dam with a majority of the fish spawning in Washington tributaries of the Columbia River. The only known stable, natural chum salmon production occurs in the Grays River, Hamilton Springs, and Hardy Creek (CBFWA 1991, Washington Department of Fisheries (WDF) et al. 1993). Hardy Creek and Hamilton Springs are the farthest upstream populations at river kilometer (rkm) 227 (Bonneville dam is rkm 232), separated by over 160 rkm from the Gray's River. Chum salmon have spawned in a side channel of the Columbia River located between Hardy and Hamilton creeks, and near Ives Island (Pierce/Ives Island Complex), but the extent of spawning production is not known. Another significant chum salmon spawning site, referred to as Wood's Landing, is located just upstream of the Interstate 205 bridge on the Washington shore of the Columbia River. The spawning area potential is being evaluated by the Washington Department of Fish and Wildlife.

The United States Fish and Wildlife Service (USFWS), Columbia River Fisheries Program Office (CRFPO), has monitored adult and juvenile chum salmon populations in Hardy Creek since 1997. In 1999, Bonneville Power Administration (BPA) funded CRFPO to monitor and evaluate chum salmon runs in Hardy Creek, Hamilton Springs, and the Pierce/Ives Island Complex. These chum salmon runs have been monitored by operating adult weirs, conducting spawning ground surveys and by operating radio telemetry sites in these areas. Continued monitoring will provide a better understanding of the life history requirements for Columbia River chum salmon.

The objectives of this ongoing project are to: 1) Examine factors limiting chum salmon production in Hamilton Springs and Hardy Creek, 2) Enhance and restore chum salmon production in Hamilton Springs and Hardy Creek, and 3) Evaluate the relationship between mainstem Columbia River and tributary chum salmon populations.

Study Area

Hardy Creek

Chum salmon migration in Hardy Creek is restricted to the lower portion of the stream (Figure 1). A culvert, which was installed during railroad construction, is an impassable barrier to chum salmon. No suitable spawning habitat exists above this culvert because the stream transitions to a higher gradient (2-10%) with a cobble substrate (USFWS unpubl. data). The lower section of Hardy Creek was re-routed and dredged in the early 1900s creating a relatively straight, entrenched channel. During this project only the lower section of Hardy Creek (downstream of the culvert) was monitored. Every 2-5 years during high runoff events and detrimental backwater effects, fine sediments deposit on available spawning habitat in lower Hardy Creek (USFWS unpubl. data).

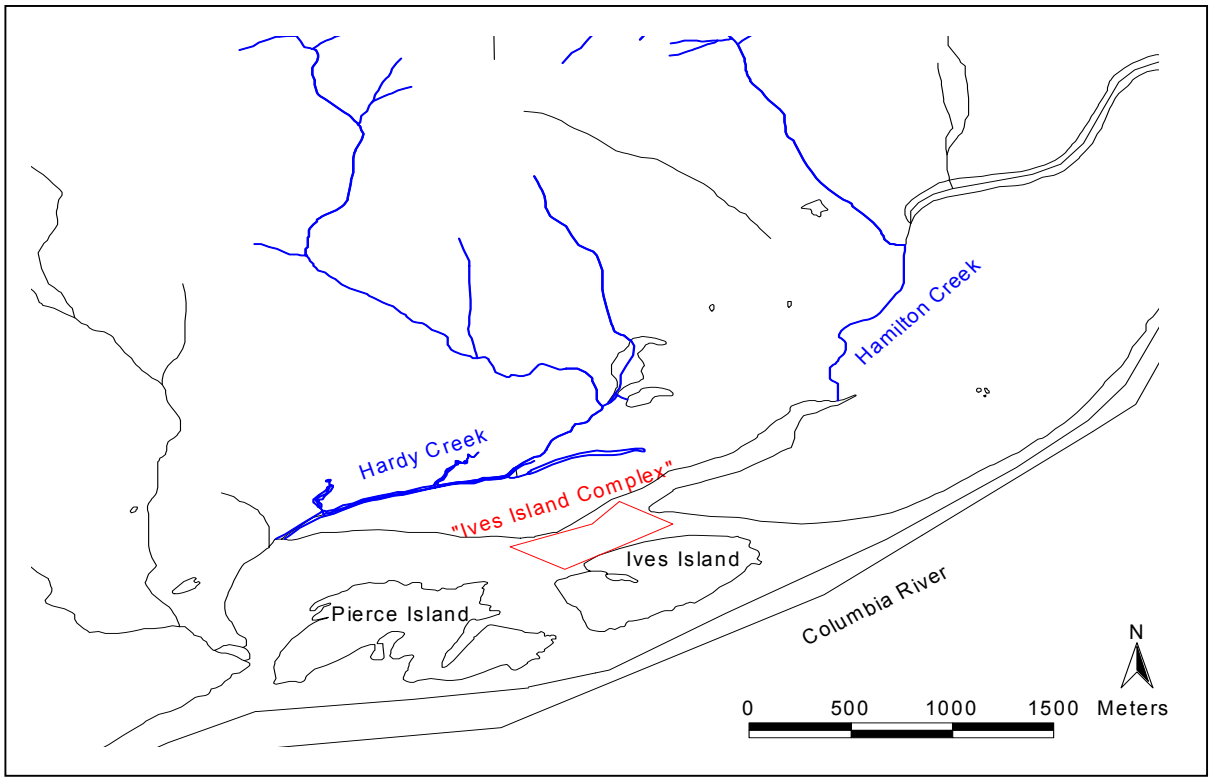

Figure 1. Area map of Hamilton, Hardy, and Ives Island chum salmon spawning grounds, 2001.

Most of the Hardy Creek watershed is public land (primarily Washington State Parks) with a small private holding bordering State Route 14. The lower portion of the stream is located on the Pierce National Wildlife Refuge. The entire watershed has been logged at least once. However, existing forests are considered second growth (approximately 35 years old) and will not be subject to future logging.

In 1996, the USFWS undertook emergency habitat restoration actions to mitigate for catastrophic flooding that destroyed essentially all of the spawning habitat available to chum salmon in Hardy Creek. This flood scoured redds and caused egg suffocation through increased sedimentation. The USFWS stabilized eroding banks, restored riparian vegetation, and exposed previously buried spawning areas. These actions allowed subsequent runs of chum salmon to successfully spawn in much of the lower section of Hardy Creek. However, habitat restoration only uncovered 0.64 linear km of spawning habitat (USFWS unpubl. data).

In August and September of 2000, an artificial spawning channel was constructed off of Hardy Creek. This spawning channel incorporates successful designs from Canada, Alaska, and Washington (Bonnell 1991; Cowan 1991). As designed, the spawning channel will not be susceptible to high runoff

events and backwater levels that might adversely affect spawning habitat. The constructed channel doubles the spawning habitat available for chum salmon in Hardy Creek. Unfortunately, it can only be operated during normal or high water years because it relies on surface water diverted from Hardy Creek.

Hamilton Creek and Hamilton Springs

The lower section of Hamilton Creek passes through the town of North Bonneville (Figure 1). This creek historically entered a side channel of the Columbia River between the mainland and Hamilton Island. During construction of the second powerhouse at Bonneville Dam, the upstream portion of the side channel was filled to join Hamilton Island to the mainland and the downstream portion became an extension of Hamilton Creek. Hamilton Creek now flows directly into the Columbia River mainstem.

In the early 1960s, an artificial spawning channel was constructed in the lower section of Hamilton Creek and is referred to as "Hamilton Springs". Hamilton Springs provides the majority of spawning habitat in this drainage. Only Hamilton Springs was monitored during this project.

Life History

Adult chum salmon return to the Columbia River at ages III to VI, although the majority return at age IV (WDF et al. 1993). Adult chum salmon return to Hardy Creek, Hamilton Springs, and the Ives Island Complex in late October and early November, often staging in the Columbia River near the confluences of the two creeks (USFWS unpubl. data).

Spawning begins when flows provide fish access into the creeks. Spawning peaks in late November and continues through December (USFWS unpubl. data). Female chum salmon enter a potential spawning area and swim slowly upstream with their noses down and fins extended, looking for areas immediately above turbulence or near areas of upwelling. They attempt to find unoccupied areas without fighting. To dig redds (nests), females turn on their sides and perform a series of four to six flexures while slapping their tails on the gravel substrate. They will typically build four to six redds in succession at one place. Redds are typically 20 to 50 cm deep and lined with substrate that allows intergravel flow. Females cover redds with gravel within seconds after egg deposition (Groot and Margolis 1991). Chum salmon usually spawn in areas of lesser depth and water velocity than other Pacific Salmon species.

Incubation and emergence are affected by stream flow, water temperature, dissolved oxygen, gravel composition, spawning time, spawner density, and genetic characteristics (Groot and Margolis 1991). Eggs develop into sac fry that remain in the gravel until the yolk sac is completely absorbed. Temperature units (TU) are defined as the number of degrees above 0° C during a 24-hour period. Chum salmon require approximately 400 to 600 TUs to hatch and approximately 700 to 1200 for yolk sac absorption. Fry begin emerging from the gravel in early to mid-February, smoltify, and outmigrate immediately (USFWS unpubl. data). The smolts migrate to their ocean feeding grounds where they remain until returning to the Columbia River to spawn. The precision of homing and the degree of straying are not well documented in chum salmon, but indications are that homing tendencies are strong.

METHODS

Adult Weir and Spawning Ground Surveys

Adult fish traps and weirs were installed and operated in Hardy Creek, Hardy Creek spawning channel, and Hamilton Springs. Captured fish were anaesthetized in a water bath containing a solution of MS-222 (tricaine methanesulfonate). Chum salmon were biologically sampled taking scales for age analysis, recording fork length, standard length, sex, species identification, development stage, and condition. Chum salmon were jaw tagged and opercle punched as a secondary mark for identification during spawning ground surveys.

Spawning ground surveys were conducted from November 15, 2001 through January 9, 2002, on Hardy Creek and Hamilton Springs. Surveys were conducted at least once a week and as many as three times weekly (weather permitting) during this period. One to three surveyors walked the stream and visually enumerated the number of live fish, redds, and carcasses. Surveyors' avoided walking through redds to minimize disturbance to spawning and staging chum salmon. Carcasses were sampled noting length, sex, species identification, gill color, % spawned, tag information, adipose fin present/absent, opercle punch location, and scales for age analysis. Tails were removed from all carcasses to prevent surveyors from sampling these fish during later surveys. Peak counts were determined by summing the number of live chum salmon and chum salmon carcasses present in the stream during the spawning ground survey.

Radio and jaw tags recovered from carcasses were used to estimate the stream life of individual fish. Stream life is defined as the time spent in the stream starting when the fish is tagged and ending when the carcass is recovered. Stream life is used along with the peak counts by the Area-Under-the-Curve program to produce population estimates (Ames 1982). Peak counts are plotted over time to produce a curve from which the program calculates the area underneath the curve. Dividing this area by the fish residence time produces a population estimate. Therefore, the population estimate is inversely related to the residence time.

Adult Movement

Chum salmon in excellent condition at capture (using tangle nets, seines or weirs) were radio tagged with a LOTEK radio transmitter (gastric implant, 148-152 Mhz). All fish fitted with radio transmitters in Hamilton Springs, Hardy Creek, and the Columbia River were monitored by nine fixed radio-telemetry stations (Figure 2). Four were located in Hardy Creek, two in Hamilton Creek, one in Hamilton Springs, one on the mainstem Columbia River and one on Ives Island. Three of the antennas in Hardy Creek and one in Hamilton Springs had two to three underwater antennae installed to pinpoint movement of the tagged adult chum salmon. The fixed radio-telemetry stations from Bonneville dam upstream to the Dalles dam, operated by the University of Idaho, also monitored movement.

Figure 2. Land based telemetry unit locations, 2001.

Juveniles

Juvenile chum salmon were trapped from early March until late June 2002. A floating fyke net modified from Davis et al. (1980) was used to capture smolts in Hardy Creek. In Hamilton Springs and Hardy Creek Spawning Channel traditional style fyke nets were used. The outmigrant traps were checked daily and all captured fish were identified by species, enumerated, and checked for marks.

Juvenile chum salmon were marked to estimate trap efficiency. During the first two marking periods, a variety of marking methods were explored. Beginning with the third marking period, fish were marked five days per week (Monday – Friday) with a Bismark brown temporary dye. Approximately 55 fish per day were placed into a 0.1 g/l solution containing Bismark brown for 30-40 minutes. These marked fish were released upstream of the trap in order to test the trap efficiency. A sub-sample of marked fish was held overnight in a live box to evaluate short-term mark retention and survival (Murphy et al. 1996). Weekly trap efficiencies were determined for each trap by the percentage of marked fish recaptured within a weekly marking period and used to estimate juvenile fish abundance. The data were tabulated and run through a Stratified Population Analysis System (SPAS) (Arnason 1996) program to produce a population estimate.

Results

Adult Weir and Spawning Ground Surveys

The Hardy Creek weir was operated from November 3, 2001 until November 14, 2001 when the resistance boards were pinned to the bottom of the creek by high water and debris. This weir was operational again from November 16, 2001 until November 24, 2001. On November 24, 2001 the resistance boards were once again pinned to the bottom by high water and debris until late winter when flow subsided. A total of six chum salmon were captured at the weir. Of these six chum salmon, four were males and two were females. One male and one female chum salmon were fitted with radio tags. Scale samples were taken from three of the fish captured in the weir. Of the three fish sampled one was age III, one was age IV, and scales from the third fish were regenerated and could not be used in age analysis.

A total of 285 chum salmon carcasses were sampled in Hardy Creek during spawning ground surveys. Of these 285 chum salmon, 189 were female and 96 were male, indicating a 2:1 sex ratio in favor of females. Two chum salmon that were fitted with radio tags were recovered during the spawning ground surveys. Scale samples were taken from 247 carcasses. Of the 247 fish sampled 132 were age III, 98 were age IV, 9 were age V, and 8 scale samples were regenerated. A population estimate was made for Hardy Creek using the Area-Under-the-Curve program, which translates to an estimated 835 chum salmon spawning in Hardy Creek for 2001.

The Hardy Creek spawning channel weir was operated between November 17, 2001 and November 25, 2001. Only one male chum salmon was captured at this weir site and its carcass was not recovered during spawning ground surveys in the channel.

The Hamilton Springs weir was operated from November 4, 2001 until November 24, 2001 when the weir was opened up to allow passage of the large number of fish that had staged in front. The staging chum salmon avoided the weir structure and passed upstream as soon as it was opened. A total of 69 chum salmon were captured at the weir. Of these 69 chum salmon 56 were males and 13 were females, indicating a 4:1 sex ratio in favor of males. Scale samples were taken from 68 chum salmon captured in the weir. Of the 68 fish sampled 49 were age III, 18 were age IV, and scales from one fish were regenerated. A total of 13 chum salmon (8 males and 5 females) were fitted with radio tags at the weir.

A total of 328 chum salmon carcasses were sampled in Hamilton Springs during spawning ground surveys. Of these 328 chum salmon, 194 were males and 134 were females, indicating a 1:1 ratio, with males slightly more abundant. Thirteen radio tagged chum salmon (eight males and five females) were recovered during spawning ground surveys. Scale samples were taken from 271 chum salmon carcasses. Of these 271 fish sampled 146 were age III, 98 were age IV, 10 were age V, and 17 scale samples were regenerated. A population estimate was made for Hamilton Springs using the Area-Under-the-Curve program, which translates to an estimated 617 chum salmon spawning in Hamilton Springs for 2001.

Adult Movement

A total of 26 chum salmon (2 collected at the Hardy Creek weir, 13 collected at the Hamilton Springs weir, and 11 collected with a tangle net in mainstem Columbia River) were fitted with radio tags and tracked using an array of fixed aerials and underwater antennae. Fifteen of the 26 chum salmon that were fitted with radio tags were recovered by USFWS personnel during spawning ground surveys. Initial evaluation of the recovery sites versus the tagging sites showed movement between the areas of Hamilton Springs, Hardy Creek, and Ives Island. Two tags were recovered outside the spawning ground survey areas at Good Bear/Archer Creek and another at Tanner Creek on the Oregon side. Two of the 11 fish that were tagged in the Columbia River were recovered in Hamilton Springs. Eleven of the 13 fish that were tagged at the Hamilton Springs weir were recovered in Hamilton Springs. The two fish that were tagged at the Hardy Creek weir were recovered in Hardy Creek.

Juveniles

In Hardy Creek, 103,315 smolts were captured. A population estimate of 450,195 (+/-21,793) was produced using the SPAS program. Fish were marked from marking periods 1-7, which produced a mean trap efficiency of 28.5% with a range of 4.4 - 72.9%. Trap efficiencies were different and not all marking periods could be pooled using the Peterson Pooled method to produce a population estimate with 95% confidence. Marking periods 4 and 5 were pooled, as were 6 and 7. Marking period 1 was significantly different from all others in the data set and could not be pooled with any others. Weekly catch, trap efficiencies, number of fish marked, and number of fish recaptured is presented in Table 2.

Table 2. Smolt capture efficiency and weekly catch for Hardy Creek, 2002.

Marking Period	Number of Fish Marked	Number of Fish Recaptured	Weekly Trap Efficiency	Weekly Unmarked Catch	Total Weekly Catch
1	140	102	72.9%	2,320	2,460
2	204	0	0.0%	7,422	7,626
3	55	0	0.0%	7,273	7,328
4	275	17	6.2%	7,501	7,776
5	275	12	4.4%	9,547	9,822
6	275	107	38.9%	45,966	46,241
7	208	42	20.2%	19,113	19,321
8	0	0	0.0%	143	143
9	0	0	0.0%	367	367
10	0	0	0.0%	1,127	1,127
11	0	0	0.0%	796	796
12	0	0	0.0%	297	297
13	0	0	0.0%	5	5
14	0	0	0.0%	6	6
15	0	0	0.0%	0	0
TOTAL	***1,432***	***280***		***101,883***	***103,315***

Two large chum salmon smolts were captured in Hardy Creek Spawning Channel during extremely high backflow from the Columbia River. It is assumed that these two smolts were pushed into the channel from Hardy Creek as no live adult chum females were passed or observed spawning in the Spawning Channel.

In Hamilton Springs, 140,220 smolts were captured. A population estimate of 561,462 (+/- 21,423) was produced using the SPAS program. Fish were effectively marked from marking periods 3-11 which produced a mean trap efficiency of 23.2% with a range of 15.5-38.2%. Trap efficiencies were not significantly different and can be pooled, using the Peterson Pooled method to produce the population estimate with 95% confidence. Weekly catch, trap efficiencies, number of fish marked, and number of fish recaptured is presented in Table 1.

Table 1. Smolt capture efficiency and weekly catch for Hamilton Springs, 2002.

Marking Period	Number of Fish Marked	Number of Fish Recaptured	Weekly Trap Efficiency	Weekly Unmarked Catch	Total Weekly Catch
1	30	0	0.0%	437	467
2	0	0	0.0%	218	218
3	257	89	34.6%	11,685	11,942
4	275	65	23.6%	24,481	24,756
5	275	105	38.2%	37,905	38,180
6	275	60	21.8%	22,414	22,689
7	220	43	19.5%	15,496	15,716
8	275	46	16.7%	10,050	10,325
9	275	48	17.5%	7,944	8,219
10	275	60	21.8%	4,305	4,580
11	220	34	15.5%	1,759	1,979
12	0	0	0.0%	781	781
13	0	0	0.0%	267	267
14	0	0	0.0%	92	92
15	0	0	0.0%	9	9
TOTAL	***2,377***	***550***		***137,843***	***140,220***

Smolts began emigrating in early March in both streams (Figure 3). Fifty percent of the population of smolt emigrated by the end of March in Hamilton Springs and by early April in Hardy Creek (Figure 3). By mid May 99% of the smolts in both creeks had emigrated.

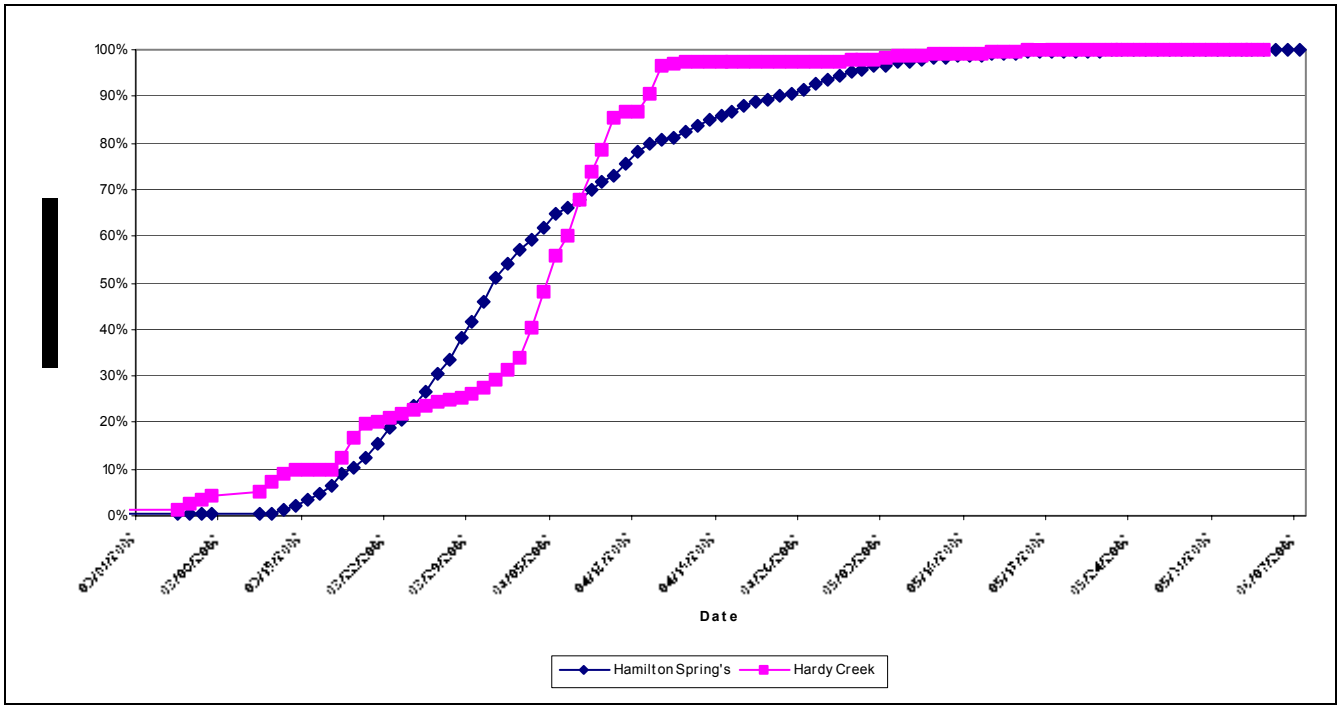

Figure 3. Smolt emigration timing for Hamilton Springs and Hardy Creek, 2002.

ANOVA tests show mean lengths of smolts per marking period to be significantly different ($P \leq 0.001$) but these differences are probably not biologically significant. Lengths differed slightly showing increase in length over time in both creeks (Figure 4). Mortalities in both streams were within the boundaries of the Section 10(a)(1)(A) permit issued by NMFS in February 2002.

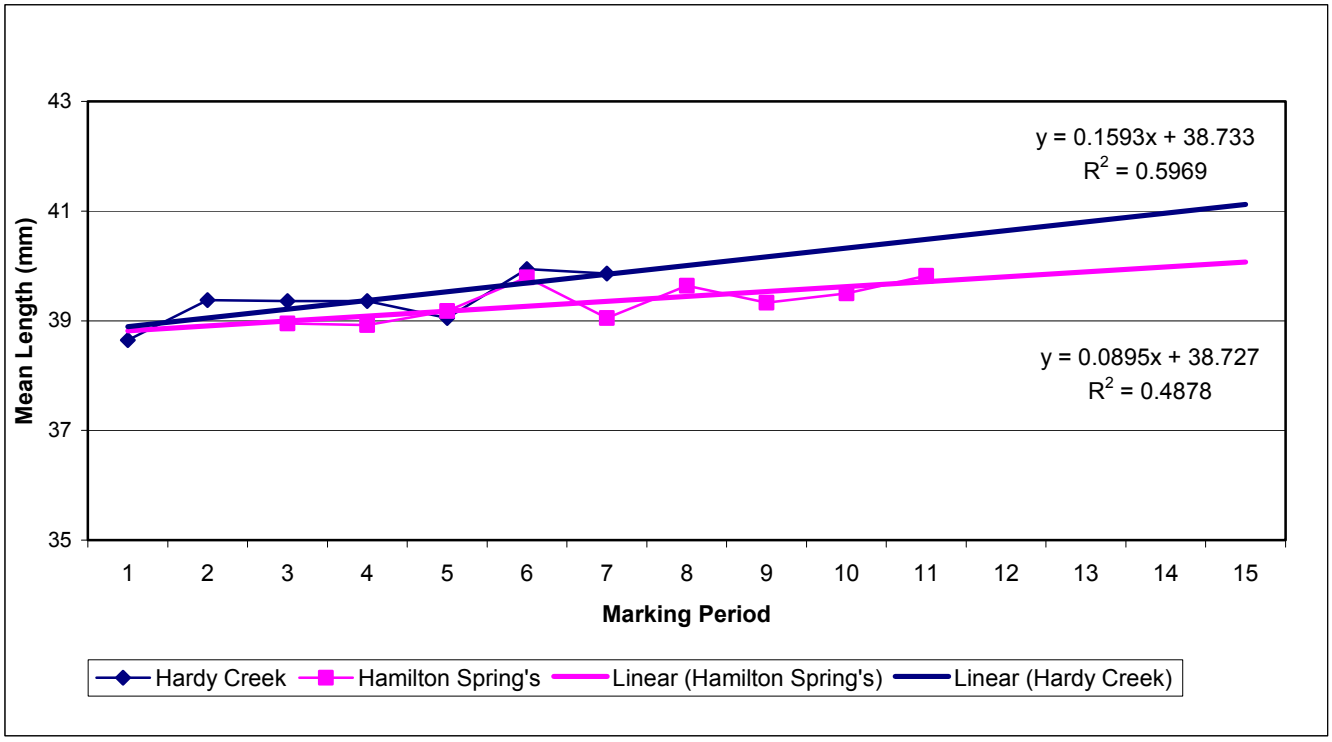

Figure 4. Mean length of smolts in Hardy Creek and Hamilton Springs, 2002.

Conclusions

Adult Weir and Spawning Ground Surveys

The weirs were not very successful at capturing chum salmon during the 2001 spawning season. Higher flows in Hardy Creek pinned the resistance board weir to the bottom of the creek for much of the season. The weir in Hamilton Springs seemed to impede chum salmon passage, which could possibly be attributed to the stream being extremely shallow and clear. Due to the fish being "trap shy" the Hamilton Springs trap was removed early to allow for unimpeded passage into the spawning areas.

Adult chum salmon population estimates were made using the Area-Under-the-Curve program. Due to higher flows and a larger number of chum salmon returning this season the Area Under the Curve program was successful at generating an estimate that fell within comparable ranges of past sampling seasons. When comparing the number of carcasses recovered this year with those recovered in 2000, there was a 60% increase in Hamilton Springs and a 91% increase in Hardy Creek. This increase may be attributed to higher flows and a larger number of chum salmon adults returning to the creeks this season. Redd counts were still difficult to make due to limited visibility in Hardy Creek and superimposition of redds in Hamilton Springs. Due to these factors accurate individual redd counts are impossible and the areas are treated as mass spawning areas.

Adult Movement

The recovery of tags during spawning ground surveys indicates that adult chum salmon moved between spawning areas. Final analysis of the radio telemetry data from the base antennas is pending completion.

Juveniles

Weekly population estimates were calculated in an attempt to group marking periods and reduce confidence intervals. Trap efficiencies in Hardy Creek were highly variable and only two pooling groups could be made from the data in order to make a population estimate assuming a 95% confidence interval. Trap efficiencies in Hamilton Springs were not statistically different and could be either grouped or left individually to produce a population estimate that assumed a 95% confidence interval. Although smolt lengths exhibited a significant difference during the ANOVA statistical analysis tests, the lack of biological differences indicate that these smolts did not hold over and emigrated shortly after emergence.

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